Calibration of the ACA System

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Science Requirement 1

- Precise imaging of **extended** objects
  - The ALMA with the ACA System should **routinely** achieve in millimeter wave

Image fideelity >20 (median) (image portion brighter than 1% of peak)

  - Similar level of fidelity for submillimeter images taken in favorable conditions

What limits the image fidelity?

- Single-dish data
  - **Pointing** error
  - **Amplitude** error

- ACA interferometry
  - **Phase** error
  - **Pointing** error

Single-dish calibration

- Single-dish mapping
  - **Pointing** error
    - Dynamic (anomalous) refraction
      Can we use N-S and E-W differential of WVR data?
  - **Amplitude** error
    - Systematic effects (e.g., scanning effect)
      Frequent calibration with the vanes (~once in 100sec)?

ACA interferometer calibration

- ACA interferometry
  - **Phase** error
    - Atmospheric phase error often too small to correct with WVR data (except for the longest baseline)
    - ACA too small to do "Fast switch"

The deciles of the rms pathlength for the 6 years of concatenated site testing data

	10m	20m	30m
20% of time	10.2	15.4	19.6 microns
50%	23.7	36.4	46.7 microns

(Holdaway, ALMA Memo in preparation)

Other Aspects

- The same approach may apply for:
  - **Primary beam**
  - **Baseline**
  - **Bandpass**
  - **Sideband gain ratio**
  - **Flux**
  - …

Possible role of ACA in Calibration

- Maintaining Flux scale data of calibrators
  - Is this needed?
  - Is this possible in a reasonable time?

- Establish a calibration scale for
  64-element + **ACA** + **single-dish**
  - ACA data can be a cornerstone to tie the datasets in a uniform amplitude scale

Galactic Center

350 micron, 20” beam (Herz on CSO)
Novak et al. ApJ 529, 241 (2000)

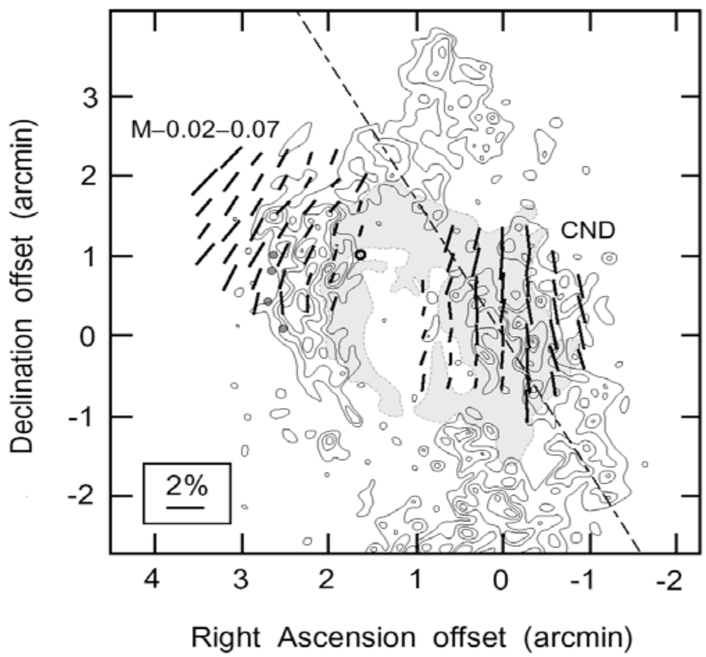

FIG. 3.—350 μm polarization results for the circumnuclear disk (CND) and M − 0.02 − 0.07, shown together with 1300 μm dust emission (*solid contours*; Mezger et al. 1989), and nonthermal radio source Sgr A East (*shaded area*, corresponding to the second lowest flux contour from the 6 cm map of Ekers et al. 1983). As in Fig. 2, the orientation of each bar indicates the inferred magnetic field direction, that is orthogonal to the measured polarization, and the length of each bar is proportional to the degree of polarization. The open circle at $(\Delta\alpha, \Delta\delta) = (+1'.5, +1')$ indicates a point where we set an upper limit of 0.6% on the degree of polarization. Filled (*gray*) circles show the positions of the four compact H II regions in M − 0.02 − 0.07 (positions were obtained from Yusef-Zadeh & Mehringer 1995). The angular resolution of the 1300 μm map is 11″. We note that the superposition of the 6 cm and 1300 μm maps shown here is identical to that of Fig. 3*b* in Mezger et al. (1989). The coordinate offsets are with respect to Sgr A*, and a dashed line drawn through the position of Sgr A* indicates the orientation of the Galactic plane.

Sgr B2

350 micron, 20” beam (Herz on CSO)
Dowell et al. ApJ 504, 588 (1998)

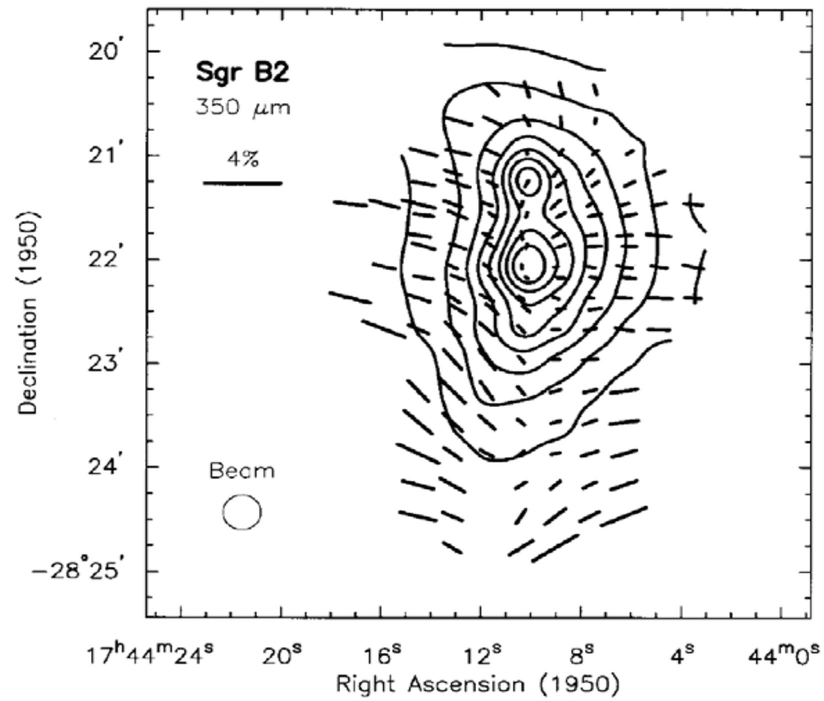

FIG. 7.—Polarization of Sgr B2 at 350 μm, measured with Hertz. The vectors show the orientation of the maximum electric field. If we assume polarization by emission, the implied magnetic field is perpendicular to the vectors. The vector length is proportional to the polarization. All of the vectors shown were detected with greater than 3 σ significance. The contours show the distribution of total flux measured simultaneously with Hertz. The contour levels are 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 times the peak flux of 3960 Jy in a 20″ beam at Sgr B2 Main (Goldsmith et al. 1990). The second peak approximately 50″ to the north of Main is Sgr B2 North.

Polarization

- How can we take reliable single-dish continuum polarization data for large sources?

  Current plan

  - OTF mapping with two fixed orthogonal linear feeds
  - Calibrate with vanes

    atmosphere, receiver gain
  - Calibrate on nearby (hopefully unpolarized) sources

    beam (antenna and receiver)

  - **Susceptible to systematic effects and sky/gain variation**

Polarization

- Mapping with **polarization rotator** needed?

  (for 12-m antennas in the ACA system only)

  Option A

  – OTF mapping with several fixed positions of the polarization rotator

  Option B

  – Point-by-point mapping with fast stepping of the polarization rotator

WVR and the ACA System

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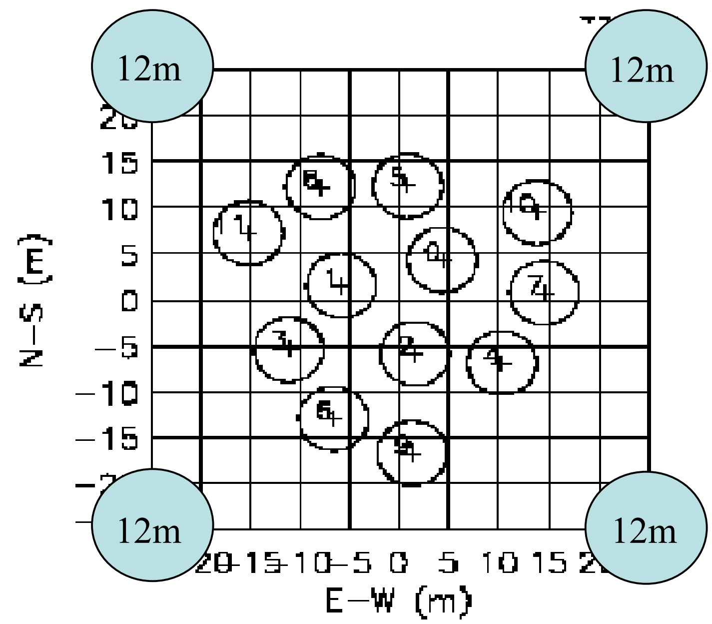
  - **Pointing** error
  - **Amplitude** error
- ACA interferometry
  - **Phase** error
  - **Pointing** error

An example of the ACA System configuration



Phase errors in ACA

- Instrumental (electronics + structure)
  - 3 micron systematic*
  - 18 micron random
- Atmospheric

Phase error corresponding to 0.6" pointing error of the 12-m dish = 35 microns

	10m	20m	30m
20%	10.2	15.4	19.6
50%	23.7	36.4	46.7
70%	43.7	66.7	85.3

Key baselines for ACA (10m–20m)

The rms pathlength in microns from the site testing data 1995-2001 (Holdaway, ALMA Memo in prep.)

WVR use in ACA

- No WVRs on the 7-m dishes
- **Use WVRs on the four 12-m dishes**
  - Measure the phase gradient over the ACA (~50 m scale)
  - Partly correct ACA phase fluctuation
  - Partly correct dynamic (anomalous) refraction

Study of the atmospheric phase structure function in 10 - 50 m scale is still important